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ABSTRACT

The structure, history, technology and especially regulation of broadcasting in general are summarized in this Federal Communication Commission (FCC) information bulletin. Further specifics of history, technology, structure and regulation are presented for AM radio, FM radio, television, educational broadcasting, and broadcast relay by satellite. (RH)

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Broadcast Services

2-B 1/72

INFORMATION BULLETIN

EM 010 069

EVOLUTION OF BROADCASTING

One of the most dramatic developments of 20th Century technology has been the use of radio waves--electromagnetic radiations traveling at the speed of light--for communication. Radio communication designed for reception by the general public is known as "broadcasting." Radio waves of different frequencies (number of cycles per second) can be "tuned." Hence, signals from many sources can be received on a radio set without interfering with each other.

In everyday language the term "radio" refers to aural (sound) broadcasting, which is received from amplitude-modulated (AM) or frequency-modulated (FM) stations. "Television," another form of radio, is received from stations making both visual and aural transmissions. AM radio, sometimes called standard broadcasting, was the earliest broadcast service and operates on relatively low "medium" frequencies. FM and TV are newer and occupy considerably higher frequency bands.

Radio communication was born of many minds and developments. In the 1860s, the Scottish physicist, James Clerk Maxwell, predicted the existence of radio waves. Heinrich Rudolf Hertz, the German physicist, later demonstrated that rapid variations of electric current can be projected into space in the form of waves similar to those of light and heat. (His contributions have been honored internationally by the adoption

of Hertz as a synonym for cycles per second.) In 1895, the Italian engineer, Guglielmo Marconi, transmitted radio signals for a short distance, and at the turn of the century he conducted successful transatlantic tests.

The first practical application of radio was for ship-to-ship and ship-to-shore telegraphic communication. Marine disasters early demonstrated the speed and effectiveness of radiotelegraphy for saving life and property at sea.

The new communication medium was first known as "wireless." American use of the term "radio" is traced to about 1912 when the Navy, feeling that "wireless" was too inclusive, adopted the word "radiotelegraph." Use of the word "broadcast" (originally a way to sow seed) stems from early U. S. naval reference to "broadcast" of orders to the fleet. Now it is used to describe radio service to the public.

The origin of the first voice broadcast is a subject for debate. Claims to that distinction range from "Hello, Rainey," said to have been transmitted by Nathan B. Stubblefield to a neighbor, Rainey T. Wells, in a demonstration near Murray, Ky., in 1892, to an impromptu program from Brant Rock, Mass., by Reginald A. Fessenden in 1906, which was picked up by nearby ships.

There were other early experimental audio transmissions. Lee De Forest put singer Enrico Caruso on the air in 1910, and there were transatlantic voice tests by the Bell Telephone Co. at Arlington, Va., in 1915, but it was not until after World War I that regular broadcasting began.

The identity of the "first" broadcasting station is also a matter of conflicting claims. This is due largely to the fact that some pioneer AM broadcast stations developed from experimental operations.

Although KDKA, Pittsburgh, did not receive a regular broadcasting license until November 7, 1921, it furnished programs under a different authorization before that date. Records of the Department of Commerce, which then supervised radio, indicate that the first station issued a regular broadcasting license was WBZ, Springfield, Mass., on September 15, 1921. (WBZ is now assigned to Boston.)

There was experimental network operation over telephone lines as early as 1922. In that year WJZ (now WABC), New York City, and WGY, Schenectady, N. Y., broadcast the World Series. Early in 1923, WEAF (now WNBC), New York City, and WNAC, Boston, picked up a football game from Chicago. Later that same year, WEAF and WGY were connected with KDKA, Pittsburgh, and KYW, Chicago (now Cleveland) to carry talks made at a dinner in New York. President Coolidge's message to Congress was broadcast by six stations in 1923.

In 1926, the National Broadcasting Co., a subsidiary of Radio Corp. of America, started the first regular network with 24 stations. In its first coast-to-coast hookup, in 1927, it broadcast a football game. In that same year, the Columbia Broadcasting System, first called the Columbia Phonograph Broadcasting System, was organized.

For some years NBC operated two networks, the Red and the Blue, but when the FCC adopted chain broadcasting rules in the early Forties, one organization was prohibited from operating two networks serving the same area at the same time. RCA sold the Blue Network to Edward J. Noble in 1943. It ultimately became the American Broadcasting Co. (In 1968 ABC itself was given a limited exception to the dual-network rule in order to operate four radio networks each providing a specific service.)

FM and TV broadcasting emerged from their experimental stage just before the United States entered World War II. Wartime restrictions retarded expansion of radio facilities, although the emergency produced new techniques and apparatus that are in use today. In the decades following the war, broadcasting expanded domestically, and the development of communication satellites has opened new possibilities for international relay.

REGULATION OF BROADCASTING

The Wireless Ship Act of 1910 applied to use of radio by ships, but the Radio Act of 1912 was the first domestic law for general control of radio. It made the Secretary of Commerce and Labor responsible for licensing radio stations and operators.

Early broadcasting was experimental and therefore noncommercial. In 1919, radio-telephone experiments were enabled to operate as "limited commercial stations." In 1922, the wavelength of 360 meters (approximately 830 kilocycles per second) was assigned for the transmission of "important news items, entertainment, lectures, sermons, and similar matter."

Recommendations of the first National Radio Conference in 1922 resulted in further regulations by the Secretary of Commerce. A new type of AM broadcast station came into being, with minimum power of 500 watts and maximum of 1000 watts (1 kilowatt). Two frequencies (750 and 833 kilocycles per second) were assigned for program transmission.

So rapid was the development of AM broadcasting that upon recommendation by subsequent National Radio Conferences in 1923 and 1924, the Department of Commerce allocated 550 to 1500 kilocycles per second for standard broadcast and authorized operating power up to 5000 watts (5 kilowatts).

Increasing numbers of AM stations caused so much interference that, in 1925, a fourth National Radio Conference asked for a limitation on broadcast time and power. The Secretary of Commerce was unable to deal with the situation because court decisions held that the Radio Act of 1912 did not give him authority. As a result, many broadcasters changed frequencies and increased power and operating time at will, regardless of the effect on other stations producing bedlam on the air.

In 1926, President Coolidge urged Congress to remedy matters. The result was the Dill-White Radio Act of 1927.

FEDERAL RADIO COMMISSION

The Radio Act of 1927 created a five-member Federal Radio Commission to issue station licenses, allocate frequency bands to various services, assign specific frequencies to individual stations, and control station power. The same Act delegated to the Secretary of Commerce authority to inspect radio stations, to examine and license radio operators, and to assign radio call signs.

Much of the early effort of the Federal Radio Commission was required to straighten out the confusion in the broadcast band. It was impossible to accommodate the 732 broadcast stations then operating. New regulations caused about 150 of them to surrender their licenses.

COMMUNICATIONS ACT OF 1934

At the request of President Roosevelt, the Secretary of Commerce in 1933 appointed an interdepartmental committee to study electrical communications. The committee recommended that Congress establish a single agency to regulate all interstate and foreign communication by wire and radio, including telegraph, telephone, and broadcast. The Communications Act of 1934 created the Federal Communiations Commission for this unified regulation. This is the statute under which the FCC operates and which it enforces. Several of its provisions were taken from the earlier Radio Act.

FEDERAL COMMUNICATIONS COMMISSION

The FCC began operating July 11, 1934, as an independent Federal agency headed by seven Commissioners, who are appointed by the President with the advice and consent of the Senate.

FCC BROADCAST REGULATION

One of the FCC's major activities is the regulation of broadcasting. This has three phases.

The first is the allocation of space in the radio frequency spectrum to the broadcast services and to many nonbroadcast services which also must be accommodated. In view of the tremendously increased use of radio technology in recent decades, the competing demands for frequencies are among the Commission's most pressing problems. Fortunately, as technology has advanced, frequencies higher and higher in the spectrum have become usable. Apart from the frequencies used for broadcasting, frequencies in other portions of the spectrum are allocated for "broadcast auxiliary" use by remote pickup and other transmitters auxiliary to main broadcast stations (see chapter on AUXILIARY BROADCAST SERVICES.)

The second phase of regulation is the assignment of stations in each service within the allocated frequency bands, with specific location, frequency, and power. The chief consideration, though by no means the only one, is to avoid interference with other stations on the same channel (frequency) or channels adjacent in the spectrum. If his application is granted, an applicant for a new station or for changed facilities receives a construction permit. Later, when the station is built and it is capable of operating as proposed, a license to operate is issued.

The third phase is regulation of existing stations: inspection to see that stations are operating in accordance with FCC Rules and technical provisions of their authorizations, modifying the authorizations when necessary, assigning station call letters, licensing transmitter operators, processing requests to assign the station license to another party or transfer control of the licensee corporation, and processing applications for renewal of license. At renewal time, the Commission reviews the station's record to see if it is operating in the public interest.

Although educational and other non-commercial stations share the airwaves, the American broadcasting system for the most part is a commercial system. In this respect it is supported by revenues from those who advertise goods or services to the audience. Advertising messages are presented as commercial "spot announcements" before, during, and after programs, or as part of "sponsored" programs.

Broadcast stations are licensed to serve the public interest, convenience, and necessity. Because radio channels are limited and are part of the public domain, it is important to entrust them to licensees with a sense of public responsibility. By law, each license must contain any right to operate the station or use the frequency beyond the term of the license. The maximum term of license is three years.

Under requirements of the Communications Act, applicants must be legally, technically, and financially qualified, and they must show that their proposed operation would be in the public interest. They must be citizens of the United States. Corporations with alien officers or directors or with more than one-fifth of the capital stock controlled by foreign interests may not be licensed.

Penalties for broadcast station violations, depending upon the degree of seriousness, range from reprimands, fines up to $10,000, and short-term probationary licenses to denial of license renewal, or even license revocation. Cease and desist orders may also be issued.

In 1965, the Commission provided for public inspection of certain records of broadcast stations in the communities they serve. These are mainly duplicate copies of records in the public files of the Commission in Washington, and include licenses, records of ownership, applications to the FCC and related material, network affiliation contracts, and employment reports.

Under the Communications Act, it is the responsibility of each broadcast licensee to program in the public interest. The Commission does not prescribe the time to be devoted to news, education, religion, music, public issues, or other subjects. Programing can vary with community needs at the discretion of the station licensee.

Licensees are expected to ascertain and meet the needs of their communities in programing. Applicants must show how community needs and interests have been determined and how they will be met. The Commission periodically reviews station performance, usually in connection with the license renewal application, to determine whether the licensee has lived up to its obligations and the promise it made in obtaining permission to use the public airwaves.

The Commission is forbidden by law from censoring programs. The Communications Act, Section 326, states: "Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication."

FAIRNESS

The Commission has held that when a station presents one viewpoint on a controversial public issue, the public interest requires that reasonable opportunity be afforded for the presentation of opposing viewpoints. This is the "Fairness Doctrine." It stems from a policy on editorializing announced in 1949, supported by a 1959 amendment to the Communications Act, which obligates broadcasters "to afford reasonable opportunity for the discussion of conflicting views of public importance." In 1967, the Commission adopted specific rules requiring stations to notify persons when personal attacks were made on them in discussion of controversial public issues (with certain exceptions such as newscasts). The same requirement was also applied to station editorials endorsing or opposing a political candidate. These rules were upheld by the Supreme Court in 1969.

SECTION 315

Section 315 of the Communications Act provides: (a) "If any licensee shall permit any person who is a legally qualified candidate for any public office to use a broadcasting station, he shall afford equal opportunities to all other such candidates for that office in the use of such broadcasting station: Provided, That such licensee shall have no power of censorship over the material broadcast under the provisions of this section. No obligation is hereby imposed upon any licensee to allow the use of its station by any such candidate. (b) The charges made for the use of any broadcast station for any of the purposes set forth in this section shall not exceed the charges made for comparable use of such station for other purposes. . ." In 1959, the Act was amended to exempt from the equal-time requirement appearances by candidates on newscasts, news interviews, and other news coverage.

A problem in connection with this statute is that it requires a station presenting one candidate to afford equal opportunities to all other legally qualified candidates for the same office, including, often, some who have no chance of prevailing in the election. In 1960 Congress suspended this requirement for the Presidential election, thus making possible the broadcast debates between the Democratic and Republican candidates without stations having to give equal time to the numerous other Presidential candidates representing small parties. A similar provision on a permanent basis, is contained in legislation passed by Congress in September 1970.

ADVERTISING

The Commission does not regulate individual commercials. In considering applications for new stations, renewals, and transfers, it does consider whether overcommercialization, contrary to the public interest, may be involved. Radio applicants proposing more than 18 minutes of commercials per hour must justify their policies to the Commission. There is not commercial quota in FCC rules, but the 18-minute benchmark is part of the National Association of Broadcasters' Radio Code. The NAB Television Code specifies a commercial maximum of 16 minutes per hour. (See section on Industry Self-Regulation.)

Under a cooperative arrangement with the Federal Trade Commission, which has jurisdiction over false and misleading advertising, the FCC notifies stations of broadcast advertising cited by the FTC so that they may take any necessary action that is consistent with their obligation to operate in the public interest.

Stations and producers of advertising are expected to cooperate in controlling the sound volume (loudness) of commercials.

"PAYOLA" AND "RIGGED QUIZ SHOWS"

Revelations about programs in the late 1950s led to amendments to the Communications Act in 1960. These made more explicit a station's obligation to make an announcemnt when money or other consideration is received for the presentation of broadcast material (e.g., money received by a disc jockey for playing a record). They made illegal the presentation of programs purporting to be contests of knowledge or skill where the result is in any way prearranged.

LOTTERIES, OBSCENITY, AND FRAUD

The U. S. Criminal Code prohibits broadcast of information concerning "any lottery, gift enterprise, or similar scheme," also utterance of obscene, indecent, or profane language, or fraud by wire, radio, or television. To be regarded as a "lottery," a giveaway arrangement must involve a prize, chance, and "consideration." A number of Commission and court decisions have dealt with these concepts in particular situations, especially as to what is "consideration." (It has been held, for instance, that having to go to a particular store or listen to a particular program is not "consideration.")

SALE OF TIME AND STATION MANAGEMENT

The Communications Act declares that broadcasting is not a common carrier operation. Unlike common carriers, broadcasters are not required to sell or give time to all who seek to go on the air, nor are they subject to regulation of rates and business affairs. Because programing is primarily the responsibility of broadcast licensees, the Commission does not ordinarily monitor individual programs, or require the filing of scripts. However, stations are required to keep logs showing the programs presented and records of requests for political time.

The Commission does not maintain surveillance of the day-to-day internal management of broadcast stations, or regulate time charges, profits, artists' salaries, or employee relations. It licenses only stations and their transmitter operators, not announcers, disc jockeys, or other personnel except where they are employed as transmitter operators. Stations are required to keep technical and maintenance logs as well as program logs.

INDUSTRY SELF-REGULATION

Radio and TV "codes" are administered by the National Association of Broadcasters for the guidance and voluntary compliance of stations subscribing to the codes. The codes govern programing and advertising practices.

NETWORKS

The Commission does not license networks as such, only individual stations. Station licensees are subject to the chain broadcasting regulations adopted by the Commission in 1941 to further competition in broadcasting. These rules have been supplemented by further regulations adopted from time to time.

MONOPOLY

One of the Commission's foremost concerns is promotion of diversification in the broadcast media, avoiding monopoly or undue concentration of control. Commission rules prohibit the same person or group from operating more than one station in the same service (AM, FM, or TV) in the same locality. They also limit to seven the number of stations in the same service that may be commonly owned in the Nation as a whole (only five of any group of TV stations may be VHF). Acquisition of more than three TV stations (only two of which may be VHF) in the 50 largest TV markets is permitted only upon a compelling showing that it would be in the public interest.

New licensees are now also prohibited from owning more than one fulltime station (AM, FM, or TV), in the same locality.

RECEIVERS

The advent of "wireless" prompted amateurs and others interested in listening-in on Morse Code radiotelegraph transmissions to acquire receiving sets. Inexpensive crystal frequency detectors boomed the production of homemade and commercially manufactured receivers. Then the rise of broadcasting aroused public interest in owning sets, battery operated at first, to receive regular programs. Receivers operated by house current came on the market about 1928. Development of the transistor in 1948 led to their use in place of tubes in sets. Successive stages in TV receiver development have taken sets from black-and-white to color, and from VHF-only to all-channel (VHF and UHF) capability (See chapter on TV BROADCAST).

The Commission does not license receivers. However, it does require manufacturers to limit radiation that may interfere with radio or TV reception.

CALL LETTERS

International agreement provides for national identification of a radio station by the first letter or first two letters of its assigned call signal, and for this purpose the alphabet is apportioned among nations. Broadcast stations in the United States use call letters beginning with K or W. Generally, those beginning with K are assigned to stations west of the Mississippi River and in territories and possessions, while W is assigned east of the Mississippi.

During radio's infancy, most of the broadcast stations were in the East. As inland stations developed, the Mississippi River was made the dividing line between K and W calls. However, KDKA, Pittsburgh, and some other eastern stations authorized before this system went into effect have retained their K calls, and similarly some pioneer stations west of the Mississippi have kept their W calls. Most of the early broadcast call signs contained only three letters. These combinations were soon exhausted and stations were assigned four-letter calls. Since many AM licensees also operate FM and TV stations, a common practice is to use the AM call letters followed by "-FM" or "-TV."

NATIONAL DEFENSE

In cooperation with military and civil defense agencies, the Commission has established the Emergency Broadcast System, based on voluntary participation by the broadcast industry. EBS facilities are for the primary purpose of giving emergency warning and advice to the public in the event of attack, but they are put to peacetime use in alerting audiences to serious weather and other emergencies threatening life and property.

BROADCAST
OPERATION

Frequencies and Station Assignments

Radio frequencies differ in characteristics, and each service is assigned to a frequency band to suit its needs.

The AM aural service, sometimes called standard broadcast, occupies the band from 535 kilocycles per second to 1605 kc/s. Radio waves travel with the same speed as light, and are of different "frequencies" (cycles per second) and "wavelengths" (distance between points in successive cycles). "Frequency" and "wavelength" vary inversely with each other. The latter term was formerly used generally to describe a particular radio wave, and still is in some other countries; but in the United States the use of "frequency" is much more common. The "medium" frequencies such as the AM band are usually referred to by their number of kilocycles (1000 cycles) per second, or, for short "kilocycles". The higher frequencies are usually referred to by the number of megacycles (1000 kilocycles or 1,000,000 cycles) per second, or "megacycles". The term "gigacycle" has come into use in more recent years, meaning 1,000,000,000 cycles per second (1,000 megacycles), to describe the much higher frequencies now being used in many services although not in broadcasting as such. The term "Hertz" as a synonym for cycle per second has recently been agreed upon internationally and domestically, along with its derivities "kiloHertz", "megaHertz", etc. The usable frequency spectrum has constantly expanded upward with developing technology, so that what were once "high" frequencies are near the low end of the total spectrum used. AM stations are assigned at 10 kc/s intervals beginning at 540 kc/s, providing 107 frequencies.

FM broadcasting occupies the frequencies from 88 to 108 megacycles per second, with 100 channels of 200 kc/s width each, the lowest 20 of them reserved for educational use. Both the center frequency (e.g., "93.1 Mc/s") and the designated channel number from 201 to 300 are used (e.g., "Channel 201" is "81.1 Mc/s"), although channel numbers are not in popular usage since they are not listed on FM receivers.

In television, where wider channels are required to carry both picture and sound, each channel is 6 Mc/s wide. The very high frequency (VHF) portion of the television service occupies the frequencies 54 to 72 Mc/s (Channels 2, 3, and 4), 76 to 88 Mc/s (Channels 5 and 6) and 174 to 216 Mc/s (Channels 7 through 13). The ultra high frequency (UHF) portion of the television service occupies the frequencies from 470 to 890 Mc/s (Channels 14 through 73). Designated channel numbers identify the frequency assignments (e.g., 54-60 Mc/s is "Channel 2"). There is no "Channel 1" in television.

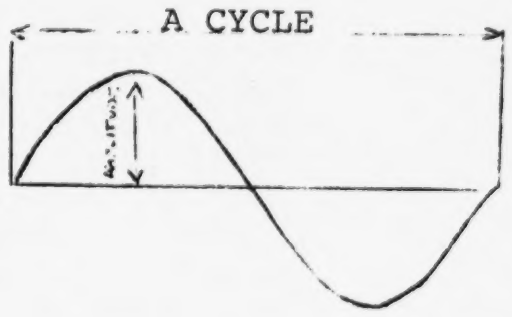
Although "AM" and "FM" are often used to refer to the standard broadcast and FM broadcast services, these terms more properly apply to methods--"amplitude modulation" and "frequency modulation"--used to impress aural or visual intelligence on the carrier wave. The "AM" principle is used not only in the standard broadcast service but also in the picture portion of television and in the international "shortwave" service. The "FM" principle is used both in the FM broadcast service and in the sound portion of television.

In all the broadcast services, the same aural or visual channel can be used in different places if the stations are far enough apart not to interfere with one another or with stations on adjacent or technically related channels. A TV station may be required to "offset" 10 kc/s above or below its normal carrier frequency. The channel assigned to such a station is then designated "plus" or "minus" as the case may be. This makes more TV assignments possible and reduces the possibility of interference.

AM and FM Systems

Without being too technical, this is how an aural station works:

A person talks into a microphone as if it were a telephone. His voice sets up vibrations of varying intensity and frequency. The lower the pitch the slower the vibration. A cycle, or wavelength, is one complete performance of a vibration.



In the microphone these vibrations are converted into electrical impulses which are then greatly amplified at the transmitter--before being put on the "carrier" wave. The intensity and frequency of the carrier wave are constant. This wave, by itself, does not transmit music or speech, so it is varied to correspond with the fluctuations of the speech or music received at the microphone. This is called "modulation."

In AM broadcast, the audio waves are impressed on the carrier wave in a manner to cause its amplitude (or power) to vary with the audio waves. The frequency of the carrier remains constant. This is known as amplitude modulation. In frequency modulation (FM), the amplitude remains unchanged but the frequency is varied in a manner corresponding to the voice or music to be transmitted.

These modulated waves radiate from the antenna tower at approximately 186,000 miles per second (the speed of light). Some of them follow the contour of the ground and are called "groundwaves." Others dart upward and are called "skywaves." At night, the skywave portions of transmissions in the standard broadcast (AM) frequencies are reflected back to earth by electrical particles in the "ionosphere" portion of the atmosphere. This gives the listener a choice of more distant AM stations at night, but also increases interference. Daytime reception is dependent on groundwaves.

Radio waves may pass through buildings and other objects but are subject to absorption or interference. As in the case of ripples on water, radio vibrations weaken with distance. Seasonal disturbances and sunspot periods can throw them off course and cause "freak" reception.

AM broadcast stations use "medium waves." That is to say, they transmit 540,000 to 1,600,000 waves a second, or 540 to 1600 "kilocycles" or "kilo-Hertz". At 540,000 waves a second, the distance between the crests is approximately 1,800 feet.

The so-called "shortwave" (international long-distance) broadcast stations transmit in the frequency range 6 MHz to 25 MHz (MHz = one million cycles/second). These waves are sent out, one after another, so rapidly that the distance between their crests (wavelength), is only about 37 to 150 feet. FM and TV stations, broadcasting in the very high and ultra high frequencies, send out even shorter, or very short, waves. (The word shortwave came into use before there was technology to use these other parts of the spectrum.)

The modulated radio wave from the radio station is picked up by the home receiving antenna. In other words, the wave sets up in the receiving antenna a current having the same frequency characteristics as the one transmitted. In the receiver the audio and carrier waves are separated by a device called a detector or demodulator. The carrier wave, no longer needed, is dissipated while the audio wave is relayed to the loud speaker where it is transformed back into the sound that is heard by the listener.

(Televison operation is discussed in the chapter on TV BROADCAST.)

Relay of Broadcasts

Simultaneous relay of broadcasting, including "networks," depends upon wire, cable, or radio connecting facilities (common carrier or private). Most live-talent radio network programs are sent over telephone circuits, many across the continent, for rebroadcast. For local broadcasts, stations usually employ wire connections between studio and transmitter, but some use radio links (see chapter on AUXILIARY BROADCAST SERVICES).

Broadcast programs can also be picked out of the air for rebroadcast. TV, because of its characteristics, cannot be sent over ordinary wire lines but depends upon coaxial cable or microwave relay. Both of these methods also handle AM and FM transmission as well as telephone and telegraph communication.

Transmitting Antennas

In the AM service, antenna height above ground is not usually a matter of much importance. The entire antenna structure acts as the antenna and usually varies in height with the frequency of the transmission. Few AM antennas exceed 1,000 feet in height and most are considerably less.

By contrast, in FM and TV, where transmission follows "line of sight," service depends on the location of the receiver in relation to the transmitting antenna. Here, antenna height is extremely important. While FM and TV antennas themselves are short, they are often situated atop natural or manmade structures which give greater height, such as tall buildings, mountain tops, or tall antenna towers specifically built for this purpose. TV towers extend as much as 2,000 feet above ground and higher.

In the interest of safety to air navigation, authorizations for broadcast transmitting antennas must usually be coordinated with the Federal Aviation Administration. Those over a certain height (usually 200 feet) must be painted and lighted. To further minimize the hazard to air traffic, shared use of tall towers, or location of all tall antennas of a given area on an "antenna farm" is being encouraged.

"Directional antennas" consist of more than one radiating element (the tower in AM), with phasing of the radiation from a series of towers so arranged that radiations cancel each other in some directions and reinforce each other in other directions. Sometimes they are used to increase radiation and service in a particular direction. More commonly the purpose is to restrict radiation in one or more directions, usually to avoid interference to other stations.

As AM stations began to multiply on shared channels, it became necessary to employ directional antennas to prevent interference. Since 1937, directional antennas have helped new stations squeeze into the congested AM broadcast band. Most fulltime (day and night) AM stations operate directionally at night. Directional antenna arrays can produce "figure eight" and more complicated service patterns. A complex array may include 12 towers. Directional antennas also are used in international communication and microwave relay to beam transmissions to particular points. Some FM and TV stations now use directional antennas.

AM BROADCAST

Amplitude modulation is the oldest system of program transmission. The pioneer AM broadcast service started operation on the low frequencies it still uses now--535 to 1605 kc/s.

AM broadcast stations use power of 250 watts to 50 kilowatts (50,000 watts) --the maximum power permitted by the Commission.

Classes of AM Stations

There are four major AM classes:

Class I stations operating on "clear" channels and usually with 50 kilowatts power (never less than 10 kw) serve remote rural areas as well as large centers of population. The U.S. has Class I priority on 45 clear channels. (Other North American countries have their own Class I priorities, some shared by the U.S.) There are only one or two Class I stations on each clear channel.

A Class II station is a secondary station on a clear channel, operating with a power of 250 to 50,000 watts. It serves a population center and an adjacent rural area and is so operated as not to interfere with the extensive services rendered by major clear channel stations (both U. S. and foreign). There are 29 channels on which Class II stations may operate.

A Class III station shares a "regional" channel with numerous similar stations, using power of 500 to 5,000 watts to serve a center of population and an adjacent rural area. There are 41 regional channels and more than 2,000 Class III stations.

A Class IV station operates on a "local" channel (shared by many similar stations elsewhere), employing a maximum power of 1 kw day, and 250 watts night. There are six local channels, each occupied by 150 or more stations.

Clear channels are frequencies set apart by international agreement for use primarily by high-powered stations designed to serve wide areas with groundwave and (at night) skywave service, particularly remote rural areas. Listeners living outside of populous communities depend for nighttime AM service on the skywave signals of distant clear-channel stations. The signals of Class I stations receive a high degree of protection from interference to make this wide service possible.

DAY AND NIGHT SERVICE

Of the two types of signal, groundwave and skywave, groundwave service is steadier, more reliable and is called "primary" service. Skywave or "secondary" service is available at night because skywave signals, lost in the daylight, are reflected from the ionosphere. Since skywaves cover tremendous distances, Class I stations can render skywave service across 700 miles or more. This service is subject to "fading," varying with changes in such factors as time of day, weather, latitude, atmospheric noise, and sunspot activity, hence the name "secondary." Because of the high power and extent of protection required for skywave signals to afford useful service, only Class I stations are authorized for skywave service.

Because skywave transmission is a factor in the AM frequencies at night, the number of AM stations operating at night must be limited. Therefore, slightly more than half of U. S. AM stations are licensed for daytime-only operation, sunrise to sunset, although on many frequencies most of them are also permitted to operate, usually with reduced power, starting at 6 a.m. when that is before sunrise (so-called "presunrise" operation).

In the early 1960s, the AM band was experiencing congestion and interference. At the same time, some service needs, such as night-time primary service to large portions of the country, were not being met. Therefore, in 1964, the assignment rules for new AM stations, or for more powerful facilities, were tightened to prevent interference and preserve the AM potential for more efficient use.

Facilities authorized from 1964 to 1968 involved minimal interference and provided the first lcoal radio outlets for a number of communities. Still there were unfulfilled service needs, particularly at night, and so in July 1968, the Commission stopped accepting AM applications while it studied how to utilize the limited potential for new stations in the AM band. At that time there were 4,215 AM stations on the air in this country; another hundred that had been previously authorized were expected to come on the air in succeeding months. There were more than twice as many AM as FM stations on the air.

The next year, new rules were proposed under which the Commission would, to a greater extent, regard AM and FM as a single aural service. New AM stations would be authorized only where they would bring a primary service to a substantial area not receiving such service from existing AM or FM stations, and would not be granted if an FM channel were available which would bring the same service benefits. FM development would be encouraged because of technical qualities of this service, including ample nighttime coverage and relative lack of interference when new stations are added.

The rules, which would be rather restrictive, are not contemplated as permanent, but rather would apply in the near future, for perhaps five years, while the Commission examines what use can best be made of the limited remaining AM spectrum space.

FM BROADCAST

Frequency-modulation broadcast has several advantages over the older amplitude modulation. FM has higher fidelity characteristics and is freer of static, fading, and background overlapping of other stations' programs.

FM's greater tonal range is due primarily to the fact that it uses a wider channel than that employed for AM broadcast. Then, too, it occupies a higher portion of the radio spectrum where there is less static and other noise than at lower frequencies. FM receivers have the particular ability to supress weaker stations and other interference.

Since the frequencies on which FM operates do not ordinarily reflect back to earth from ionospheric layers (in skywaves), it is possible for many scattered FM stations to use the same frequency without interference, night or day, unlike the AM band.

FM and AM broadcast do not interfere with each other since they are on widely separated bands. Because of the difference in their spectrum locations and the systems used, FM cannot be heard on AM receivers without special adapters. Likewise, AM cannot be heard on sets made to receive only FM. However, combination sets receive both systems. Legislation has been proposed to require all radio sets to have both AM and FM capability, just as TV sets are required to receive both VHF and UHF channels.

History

The principle of frequency modulation has long been known, but its advantages for broadcasting were not realized until shortly before World War II. Largely as a result of interest evoked by extensive developmental work by Edwin H. Armstrong in the 1930s, the Commission authorized increased FM experimentation, and in 1940, after extensive public hearings, provided for FM operation to start January 1, 1941. It set apart 35 channels for commercial and 5 channels for noncommercial educational FM.

On October 31, 1940, the Commission granted construction permits for the first 15 FM stations. By the end of that year there were 10 more. Though all radio construction was frozen during World War II, more than 40 prewar FM stations continued to serve some 400,000 receivers.

FM stations were initially assigned call letters with numerals added, but in 1943 the present letter system was adopted. There is optional use of the suffix "-FM" to distinguish these stations from jointly-operated AM stations.

Because of skywave interference experienced on the original FM band at 42-50 megacycles per second, the Commission in 1945 moved FM to its present higher and less vulnerable position in the radio spectrum, 88 to 108 Mc/s. At the same time it increased the number of channels to 100, providing 80 for commercial and 20 for noncommercial educational use.

FM Zones and Classes

In 1962, the Commission revised its commercial FM rules to divide the country into three zones (instead of the previous two). Zone I includes part or all of 18 Northeastern states, plus the District of Columbia; Zone I-A is limited to Southern California, and Zone II includes the rest of the country.

Three classes of commercial FM stations (instead of the previous two) were created. Class A stations are assigned to all zones; Class B stations are assigned to Zones I and I-A, and Class C stations are assigned to Zone II.

Class A stations are low-powered with a maximum of 3 kilowatts effective radiated power. The maximum power for Class B stations is 50 kw and for Class C, 100 kw.

An important factor in FM operation is the height of the antenna above surrounding terrain (see earlier section on Transmitting Antennas, line-of-sight transmission). Therefore stations have maximum antenna heights in relation to power, 300 feet above average terrain for Class A, 500 feet for Class B and 2,000 feet for Class C. If the antenna height above average terrain is greater, power must be reduced commensurately. Minimum power requirements are also prescribed.

FM reception varies with location of the receiver in relation to the transmitting antenna. With maximum power and antenna height, good service extends about 15 miles for Class A stations, 33 miles for Class B, and 64 miles for Class C. The rules also include minimum mileage separations between stations on the same or adjacent channels. This is to protect the service from interference.

In 1963 the Commission adopted a table assigning commercial FM channels to states and communities. (This is similar to the TV table of channel assignments.) Nearly 3,000 FM channel assignments were made to nearly 2,000 mainland communities. Assignments in Alaska, Hawaii, Puerto Rico, and the Virgin Islands were added in 1964.

FM stations owned jointly with AM stations in cities of more than 100,000 population may not duplicate AM programing for more than half the FM station's broadcast week.

The Commission has said it believes that separate ownership of AM and FM stations is a desirable long-range goal.

Subsidiary FM Service

To aid FM broadcasters, the Commission in 1955 enabled them to apply for subsidiary communications authorizations for suplemental service such as background music. Sometimes called "functional music," this specialized service is offered to stores, factories, and other business subscribers.

Originally subsidiary communications were permitted on a simplex basis, the station devoting part of the time on its channel to regular broadcasting and part to this specialized service. Later, rules were adopted requiring subsidiary communications to be on a multiplex basis, that is, using one or more subchannels with the main channel used for regular broadcasting. Subsidiary communications transmissions are received on special sets in the stores, offices, and plants of subscribers.

Stereophonic Service

Stereophony is not really a 20th Century innovation but dates back to experiments performed over wire lines by telephone engineers in the 1880s. Even at that time contemporary accounts spoke of being able to "localize" a singer's position on an opera stage by virtue of the signal strength in either the right or left telephone. Over the next few decades, there were other experiments in transmitting binaural sound, but the general impetus to development came only with post-World War II technology in which multiplexing techniques were applied to FM broadcasting. In 1959, the National Stereophonic Radio Committee was created to examine the many proposed systems of FM stereo and submit a final recommendation

to the Commission. In the summer of 1960, six systems were field tested over KDKA-FM in Pittsburgh, with receivers set up at Uniontown, Pennsylvania. The system of stereo transmission proposed by the General Electric Co. and the Zenith Corp. was adopted, with broadcasting authorized to start on June 1, 1961.

TV BROADCAST

Television broadcasting is synchronous transmission of visual and aural programs. The picture phase is accomplished by sending a rapid succession of electrical impulses which the receiver transforms into scenes and images. Here is a brief explanation of a complex process.

Monochrome

The scene to be televised is focused on a special tube in the television camera which has a small "screen" covered with about 367,000 microscopic dots of a special photo sensitive substance. This can be likened to a tiny motion picture screen and is called a "mosaic." The varying light from each part of the scene being televised falls upon these dots and gives them an electrical charge, the strength depending upon the amount of light falling upon the individual dots. Thus each dot becomes a tiny storage battery and the scene is formed in a pattern of electrical charges on the mosaic.

The mosaic is "scanned" by a tiny beam of electrons, no larger than the head of a pin, moving from left to right and progressing downward (just as the printed page is read by the human eye). This complete process is repeated 60 times per second, and the horizontal lines of alternate scanning are interlaced so that 30 complete pictures or "frames" composed of 525 horizontal lines are produced each second.

As the electron beam strikes each dot on the mosiac, the dot is discharged through the electron beam and the electrical impulses produced are used to modulate the signals of the TV transmitter. Each time the dots are discharged by the electron beam they are recharged by the light produced by the succeeding scene falling upon them. The succession of individual "still" scenes creates the illusion of motion just as in the case of motion picutres made on film.

The reproduction by the TV receiver of the pictures transmitted is just the reverse of the transmission. The incoming succession of electrical impulses is separated from the "carrier," and after amplification is impressed on the picture tube grid. The picture tube also has an electron "gun" which shoots out a tiny beam of electrons which moves from left to right and progresses downward on the face of the picture tube.

The face of the tube is coated with a material which fluoresces or gives off light at the point where it is struck by the electron beam. In the absence of a television signal, the whole face of the picture tube is illuminated equally by a series of closely spaced horizontal lines. When a TV signal is placed on the grid of the picture tube, it controls the strength of the electron beam and hence the amount of light on the face of the tube. If the scanning of the electron beam in the picture tube is kept in perfect step with the scanning of the electron beam in the TV camera, the picture tube will reproduce the lights and shadows of the subject scene, and the succession of such scenes produces the illusion of motion.

In brief, the picture seen by the viewer is actually produced by a flickering spot of light moving rapidly across and down the face of the picture tube. The viewer sees the "whole" picture because the screen continues to glow for a tiny fraction of a second after the electron beam has passed. Coupled with the retentive ability of the eye, this creates the illusion that the picture is there all the time. The high rate of repetition of the picture produced by the beam minimizes flicker and lends smoothness to motion.

The TV transmitter is, in effect, two separate units. One sends out the picture and the other the sound. Visual transmission is by amplitude modulation. Sound transmission is by frequency modulation.

In color TV, a brightness component is transmitted in much the same manner as the black-and-white picture signal is sent. In addition, a color component is transmitted at the same time on a subcarrier frequency located between the visual and aural carrier frequencies.

Color standards are based on a simultaneous system of color transmission. Signals representing red, blue, and green are transmitted simultaneously. These are the "primary colors," and when they are combined in various amounts, they produce all of the other colors. A magnifying-glass examination of the scene on a receiver will reveal that it is made up only of red, blue, and green dots, no matter what color is being shown. Even scenes not transmitted in color and seen as varying shades of gray to white are made up of red, blue, and green dots.

Only color receivers have the special picture tubes and the necessary circuitry to illuminate the colored dots. Under the "compatible color" system, color programs can be received in black-and-white on monochrome sets, and black-and-white programs can be received as they are on color sets.

History

Men of many lands contributed to the development of television. Like aural radio, TV was made possible by electronic discoveries in the late 19th and early 20th centuries. In 1884 Paul Nipkow, a German, patented a scanning disc for transmitting pictures by wireless. In this country Charles F. Jenkins began his study of the subject about 1890. The English physicist, E. E. Fournier d'Albe, conducted experiments in the early 1900s. In 1915 Marconi predicted "visible telephone."

In 1923 physicist Vladimir Zworykin, a Russian-born American, applied for a patent on the iconoscope camera tube. In the years following there were experiments by E. F. W. Alexanderson and Philco T. Farnsworth in this country and John L. Baird in England. An experimental TV program, in which Secretary of Commerce Herbert Hoover participated, was sent by wire between New York and Washington by the Bell Telephone Laboratories in 1927. The next year Bell experimentally televised outdoor programs.

The Federal Radio Commission (predecessor of the FCC) reported that a few broadcast stations were experimenting with television in 1928. In that year WGY, Schenectady, broadcast the first TV drama. Large-screen TV was demonstrated by Radio Corp. of America (now RCA Corp.) at a New York theater in 1930. RCA tested outdoor TV pickup at Camden, N. J., in 1936.

By 1937 there were 17 experimental TV stations operating. The first U. S. President seen on TV was Franklin D. Roosevelt, when he opened the New York World's Fair in 1939. That year saw the first telecast of a major league baseball game, a college football game, and a professional boxing match. In 1940 the Republican and Democratic conventions were first televised. Pioneer use of coaxial cable for long-distance relay was made for the Republican convention.

The first President's message to Congress over network TV was that of President Truman in 1950. The first TV debate between Presidential candidates was in 1960 between Kennedy and Nixon. The first Presidential message to Congress televised in color was that of President Johnson in 1966.

Early Commercial Operation

The Journal Co. of Milwaukee, now licensee of WTMJ-TV, filed the first application to broadcast TV on a commercial basis. At a 1940 hearing the FCC found industry divided on technology and standards, but a committee appointed to work on the questions reached agreement on the present standards of 525 lines and 30 frames per second, and on April 30, 1941, the Commission authorized commercial TV operations to start the following July 1, on 10 commercial stations which were on the air by May 1942, six continuing during the war.

In 1945 the Commission allocated 13 VHF channels between 44 and 216 Mc/s for commercial television, but it noted that there was not enough spectrum space below 300 Mc/s for an adequate nationwide system. Twelve of the VHF channels had to be shared with nonbroadcast twoway radio services. To prepare for TV expansion, the UHF frequencies between 480 and 920 Mc/s were made available for experimental TV and those between 1245 and 1325 Mc/s for TV relay.

In 1948, because of interference with commercial TV, the VHF sharing was ended. TV Channel 1 (44-50 Mc/s) was deleted and assigned to land mobile or two-way radio service.

TV Proceedings 1948-1951

As the Commission had foreseen, it was increasingly evident that the available channels were too few for nationwide service. On September 30, 1948, the Commission stopped granting new TV applications in order to study the situation. This was the so-called TV "freeze" order. On July 11, 1949, comprehensive changes were proposed to improve and extend TV service. These included new engineering standards, opening UHF channels for TV, consideration of color systems, reservation of channels for noncommercial educational use, and a national assignment plan for all channels.

Color was considered first. Three competitive systems were offered for Commission consideration. They were the "field sequential" system of Columbia Broadcasting System, Inc., the RCA "dot sequential" system, and the Color Television, Inc., "line sequential" system. The Commission found that the field sequential system was the only one that met its criteria for color operation, even though this system could not be received in monochrome or existing receivers (the others claimed theirs could). This method of operation was adopted in 1950, but the door was left open for development of a better system.

CBS began limited color broadcasts on June 25, 1951, but ran into problems. Because of a materials shortage, the National Production Authority on the following November 20, prohibited manufacture of color TV sets for the public, and interest in the field sequential system lagged.

Thereafter new standards for "compatible color", receivable both in color and monochrome, were developed by RCA and advocated by the industry through its National Television System Committee. These standards were adopted by the Commission on December 17, 1953.

Freeze Lifted 1952

On April 14, 1952, the Commission reopened TV to expansion. It added 70 UHF channels (between 470 and 890 Mc/s) to the 12 VHF channels (54-216 Mc/s). It adopted a table making more than 2,000 channel assignments to nearly 1,300 communities. These included 242 assignments for noncommercial educational use.

The minimum effective radiated visual power of TV stations was set at 100 watts. The maximum varies with antenna height (no minimum height above average terrain is specified). On VHF Channels 2-6, maximum power is 100 kilowatts; on Channels 7-13 it is 316 kw; and on UHF Channels 14-83, it is 5,000 kw. With very high antennas the amount of power used is reduced.

Separation of stations on the same channel is determined by three geographic zones. In Zone I, minimum co-channel separation is 170 miles for VHF channels and 155 for UHF. This zone covers Massachusetts, Rhode Island, Connecticut, New Jersey, Maryland, Pennsylvania, Delaware, District of Columbia, Ohio, Indiana, Illinois, and parts of Maine, New Hampshire, Vermont, New York, Virginia, West Virginia, Michigan, and Wisconsin.

In Zone II, minimum co-channel separation is 190 miles for VHF and 175 miles for UHF channels. This zone includes Kentucky, Tennessee, North and South Carolina, Missouri, Iowa, Minnesota, Arkansas, Kansas, Nebraska, Oklahoma, North and South Dakota, Utah, Idaho, Arizona, New Mexico, Montana, Wyoming, Nevada, Colorado, Oregon, Washington, California, Alaska, Hawaii and parts of the States of Maine, New Hampshire, Vermont, New York, Virginia, West Virginia, Georgia, Alabama, Mississippi, Louisiana, Michigan, Wisconsin and Texas.

In Zone III the separation is 220 miles for VHF and 205 miles for UHF channels. This zone includes Florida, parts of Georgia, Alabama, Louisiana, Mississippi and Texas.

The first commercial TV grants after the freeze were made July 11, 1952, to three Denver stations. The first commercial UHF station to go on the air was KPTV, Portland, Oregon, on September 20, 1952.

TV Service

Commercial TV stations are required to broadcast at least 28 hours a week, at least two hours every day, although they are allowed a shorter schedule when they begin operation.

TV service may be expanded to new areas through use of "satellite" stations--regular stations largely rebroadcasting the programs of parent stations--and "translators", lower power automatic installations which pick up and rebroadcast programs of parent stations on a different frequency. The rules also provide that UHF stations may use "boosters", lowpower stations rebroadcasting on the same frequency, to fill in "shadow" areas within their normal service areas. These have not proved satisfactory and none are now in operation. Rebroadcasting requires the consent of the originating stations.

Unlike AM networking over ordinary telephone wires, TV networking requires special relay adjuncts. Network TV was made possible in large measure by the development of coaxial cable and microwave relay facilities. As early as 1937 motion pictures were televised and sent over the coaxial cable link between New York and Philadelphia. Network operation was begun by WNBT (now WNBC-TV), New York City; WRGB, Schenectady; and WPTZ (now KYW-TV), Philadelphia, in 1914.

Regular coaxial-cable relay service was inaugurated between Washington and New York in 1946. The following year microwave relay service extended as far as Boston. A midwestern relay system, opened in 1948, was joined with the eastern system in 1949. The first link in the transcontinental relay system was opened between New York and Chicago in 1950. It reached San Francisco the following year, and on September 4, 1951, it carried telecasts of the Japanese peace treaty conference.

Programs are carried between coasts now mostly by microwave, with cable used for local loops where microwave is not feasible. Although there is some private microwave TV relay, most life networking is over the facilities of common carriers. American Telephone & Telegraph Co. is the dominant carrier nationally.

"Subliminal Advertising"

There have been experiments with transmission of brief visual messages, aimed below the threshold of conscious perception, but they were dropped. So-called "subliminal advertising" is frowned upon by the television industry. There is none on the air, and so the Commission has not adopted any rules on the subject.

UHF Development

Economic and technical problems have impeded full utilization of the UHF channels. Because of the large number of VHF-only receivers originally in use, advertisers have preferred VHF stations, limiting UHF revenue.

In 1956 the Commission outlined plans to promote comparable TV facilities as a means of extending service throughout the nation. In the years following, it considered and rejected the idea of moving all or most of TV to the UHF band. It sought the cooperation of industry to find ways to increase the range of UHF stations. It made certain areas all-UHF and took other steps to put UHF and VHF on a more competitive basis. In 1966 it revised the table of channel assignments to make additional UHF assignments.

At the Commission's request, Congress appropriated money for a test in New York City to determine the ability of UHF to provide service comparable with VHF in a locality of difficult reception because of tall buildings separated by "canyons." As a result of the tests, the Commission concluded that UHF reception, generally, was equal to that of VHF.

Also at FCC request, Congress in 1962 adopted a law permitting the FCC to require that all TV receivers be made to receive UHF as well as VHF channels. Industry had to convert to all-channel production by April 30, 1964. This has given substantial impetus to UHF expansion. A lingering complaint was that VHF tuning dials, which clicked into place, were easier to work than UHF, which worked like aural radio dials. Efforts were launched to make UHF tuning more comparable with the click-action VHF tuning, and rules were adopted in 1970 to require comparability.

Community Antenna or Cable TV

Community antenna TV (CATV) is not a broadcast service. It augments broadcast service and it is regulated by the FCC, but CATV systems are not licensed as broadcast stations are.

CATV systems pick up the programs of broadcast stations by a central receiving antenna or by microwave radio relay. Coaxial cable, which can carry many signals, delivers them from the reception point to the homes of the subscribers.

CATV started in 1949-50 as a means of bringing TV service to communities outside the reach of broadcast signals. It spread to communities that had TV service but wanted to receive more stations. Other markets were found where there was already a choice of signals but where obstacles to over-the-air reception gave cable operators an opportunity to promise a better picture.

The Commission began to regulate CATV in April 1965 when it adopted rules for microwave-served CATV systems. It required them to carry the signals of local stations and to refrain from duplicating the programs of local commercial stations (by carrying other stations broadcasting the same programs) within 15 days of the local broadcast. In October of that year, special frequencies were made available for relaying signals to CATV systems.

In 1966 the Commission required all CATV systems to carry local and nearby stations and to protect their programs from duplication, although the 15-day requirement was reduced to protection the day of broadcast. It also set a hearing requirement on proposals to bring distant signals into communities regularly served by TV stations in the 100 largest TV markets.

The Commission proposed new CATV rules in December 1968. Adopting some of these the following October, it required systems with more than 3,500 subscribers to originate programing as of 1971. This was designed to bring local outlets to communities without stations. The broadcast requirements of fairness and sponsor identification were extended to CATV.

Subscription TV

Subscription television is a special program service for viewers who pay for it. It is transmitted over the air in scrambled signals which are deciphered by devices on subscribers' sets.

The Commission first authorized experimentation with over-the-air pay TV in 1950. Five years later it invited comments on whether it would be in the public interest to establish a pay TV service on a permanent basis. In 1957 it said trial demonstrations would be needed to resolve the question, but in view of resolutions by two Congressional committees, it deferred action for two years. In 1959 it invited trial pay TV applications by commercial stations. After a hearing, an application by WHCT(TV), Hartford, Conn., for use of UHF channel 18 was granted in 1961, and trial pay TV began in the summer of 1962. It was voluntarily ended by the station in January 1969.

Commission rule making began in 1966. After studying comments and the Hartford data, the Commission's Subscription Television Committee proposed to authorize a new national service. The Commission heard oral argument on the proposal in the fall of 1967. On December 12, 1968, the Commission established over-the-air pay TV as a permanent service. The beginning of service awaited approval of applications to operate pay TV stations.

Over-the-air pay TV is designed to be a supplemental service to conventional broadcasting. Only one station in a community may be granted a pay TV authorization and only where at least four conventional TV stations, in addition to the proposed pay TV station, serve the community. There are safeguards in the rules to prevent pay TV stations from siphoning programs from conventional television. For example, with some exceptions pay TV may not show feature films more than two years old. There is also a rule that bars from pay TV any sports programs regularly shown in the community over conventional TV during the previous two years. It is proposed to extend this prohibition to a five-year period as a further protection against siphoning.

EDUCATIONAL BROADCASTING

AM

Educational institutions were among the pioneers in experimental broadcast, and they held many early AM licenses.

By 1925 educational groups had 171 AM licenses. For various reasons, notably the increased competition from commercial broadcasting, most of these stations were off the air by 1934 when the FCC was created. However, there are still two dozen educational stations operating in the AM broadcast band, although there are no longer any educational allocations there (see section on FM below).

As directed by Section 307(c) of the Communications Act, the Commission in 1934 studied a proposal that Congress allocate fixed percentages of radio facilities for nonprofit programs. On January 22, 1935, the FCC recommended against such a statutory allocation but recognized the need for extending broadcasting to education. It expressed an intention "actively to assist the determination of the rightful place of broadcasting in education and to see that it is used in that place."

FM Educational Stations

When regular FM broadcasting was authorized in 1941, five channels were authorized for noncommercial educational use as a substitution for AM allocations previously made to education.

In 1945, as part of an extensive revision of frequency allocations, the Commission reserved 20 FM channels between 88 and 92 Mc/s for noncommercial educational FM stations. This part of the FM band is contiguous to the commercial portion, and FM receivers can tune both noncommercial and commercial stations. Since then the number of noncommercial educational FM stations has grown slowly but steadily.

In 1948 the Commission authorized 10-watt operation on educational FM channels. With such low-power equipment, easily installed and operated, schools may broadcast to a limited area of two to five miles for an outlay of a few thousand dollars. Higher power equipment may be added when desired. In 1951, as a further aid, the Commission authorized remote control operation of low-power educational stations. Approximately half of all educational FM stations use power of 10 watts.

Educational FM stations traditionally have been assigned on an individual-application "demand" basis, as AM stations are assigned. To permit planned development of the 20 reserved channels, it is proposed to adopt a Table of Assignments, like that adopted in 1963 for commercial FM channels, to allocate specific frequencies to communities.

Stations in the educational FM service are licensed principally to school systems, colleges, and universities for student-teacher programs as well as for public education and information.

TV Educational Stations

The Commission allocated TV facilities for noncommercial educational use after a lengthy study in the general television proceedings (see Broadcast). It determined that "the need for noncommercial educational stations has been amply demonstrated," that it would take longer for the educational service to be developed than for the commercial service, and that special channels should be reserved.

Consequently, in 1952, channel assignments were made to 242 communities exclusively for noncommercial educational stations. Forty-six of these were made to primary educational centers. Of the total 242 channels, 80 were VHF and 162 UHF. There have been more assignments since. In 1966 a revised table of channel assignments was adopted for UHF, containing many more educational assignments than before. The new table contains altogether over 615 educational TV assignments in the mainland states, more than a third of all channel assignments.

The first educational TV station to go on the air was KUHT, Houston, Texas, on May 25, 1953. The first state educational TV network was established in Alabama on April 28, 1955.

The Commission expects educational TV licensees to make their station facilities available to other local educational institutions, since such assignments are made to serve the educational and cultural needs of the community. Except in particular cases, educational TV eligibility is not extended to municipal authorities in places where an independent educational authority, such as board of education, is established. Noncommercial educational stations are not required to broadcast a specific minimum number of hours, but educational and commercial TV stations are subject to the same service requirements, such as station separation, antenna height and power.

A 1962 law enabled the Department of Health, Education, and Welfare to make matching Federal grants of money to build educational TV stations, and a 1967 law extended these benefits to educational radio.

As an aid to educational TV, the Commission in 1963 established the Instructional Television Fixed Service, a nonbroadcast service on considerably higher frequencies (2500-2690 Mc/s) than the broadcast service. An ITFS station at a central point such as a school-district headquarters can transmit as many as four programs simultaneously to area schools, where special receivers pick up the programs. Simultaneous transmission capability eases scheduling programs for in-school educational TV, and the ITFS service frees broadcast educational TV for more general programing.

(Many schools have closed-circuit TV systems to link classrooms for instruction, but this is by cable, not broadcast, and it is not regulated by the Commission.)

Several colleges, universities, and community groups hold TV authorizations on channels not reserved for education, and they operate either on a profit or nonprofit basis.

INTERNATIONAL BROADCAST

Under international agreement, certain high-frequency bands are allocated for broadcast between nations.

Authorizations for non-Government international broadcast stations in the United States are issued by the FCC. Only three of these international stations are now authorized. A single station uses a number of frequencies between 5950 and 26100 kHz, and it may need more than one transmitter, because of seasonal considerations and other factors in broadcasting different programs simultaneously to different parts of the world. The three stations have a total of seven transmitters, all located in this country. The minimum power for these stations, sometimes known as shortwave stations, is 50 kilowatts.

During World War II, international broadcast stations in the United States were taken over temporarily by the Office of War Information and the Office of Inter-American Affairs of the Department of State, which programed them in the interest of the war effort.

Under the peacetime program of the Department of State, the United States Information Agency broadcasts daily in many languages to other parts of the world through the Voice of America. VOA stations are not licensed or regulated by the FCC. There are about 30 VOA transmitters in the United States, and about 70 located in foreign countries.

BROADCAST RELAY BY SATELLITE

The first live transatlantic telecast by satellite was relayed by Telstar I on July 10, 1962. The picture was of the American Flag fluttering in front of the sending station at Andover, Maine. More panoramic telecasts, showing life in widely distant places, were exchanged between the U. S. and Europe thirteen days later. Telstar I and other experimental satellites were operated by the National Aeronautics and Space Administration, which continues to handle the rocket launching of privately-operated communication satellites as well as some satellites in Government communication and space programs.

The Communications Satellite Act of 1962 provided for the U. S. portion of a global system to be operated by a private corporation, the Communications Satellite Corp., subject to Federal regulation. Comsat is owned partly by common carriers and partly by the general public. Early Bird (INTELSAT I) on April 2, 1965, became the first commercial satellite to be put in orbit by Comsat and its foreign partners in the International Telecommunications Satellite Consortium. During the following year, some 80 hours of television were transmitted between the U. S. and Europe. Early Bird has since been replaced and retired.

When INTELSAT II (Flight 2) went up over the Pacific on January 11, 1967, satellite communication was established between the U. S. mainland and Hawaii, making live network TV transmission available there for the first time. Still, television makes up only a small part of the traffic on communication satellites around the world. Telephone and teletype communications, including data transmissions, dominate the loads.

The Commission is now also considering applications for satellites for domestic use within the United States.

AUXILIARY BROADCAST SERVICES

Broadcasters take portable or mobile transmitters to the scene of events to relay aural programs back to the station for on-the-spot coverage of sporting events, parades, conventions, fairs, disasters, and other newsworthy events. These remote-broadcast pickup stations use frequencies in the 26, 153, and 450 Mc/s portions of the spectrum.

TV stations also use small portable transmitters operating in the 2, 7, and 13 gigacycles per second (microwave) portions of the spectrum for visual coverage of out-of-studio events.

Stations may also use transmitters to send TV and aural programs from the studio to the transmitter (studio-transmitter links) and to relay programs between broadcast stations (intercity relay stations). Aural studio-transmitter links and intercity relay stations operate in the 950 Mc/s portion of the spectrum and TV studio-transmitter links and intercity relay stations in the 2, 7, and 13 Gc/s portions.

EXPERIMENTAL BROADCAST

Experimental broadcast stations test new techniques and develop broadcast equipment. Information obtained helps the industry to evolve and provides the Commission with information about new developments. All the broadcast services (AM, FM, TV) had their origins in experimental stations, as did UHF television, color television, and subscription television. Because of their temporary nature, experimental station authorizations fluctuate in number.

GROWTH OF BROADCAST SERVICE

These tables show the development of broadcasting. The number of stations is as of January 1 of the year noted.

Commercial TV Stations in Operation

Year	Total	VHF	UHF
1945	6	-	-
1950	97	-	-
1955	439	-	-
1960	573	-	-
1965	586	487	99
1966	598	491	107
1967	620	497	123
1968	648	504	144
1969	675	506	169
1970	690	508	182
1971	696	511	185

TV Financial Data
($ Millions)

Year	Revenues	Expenses	Income 1/
1952	$ 324.2	$ 268.7	$ 55.5
1953	431.8	360.5	71.3
1954	592.9	502.6	90.3
1955	744.7	594.5	150.2
1956	896.9	707.3	189.6
1957	943.2	783.2	160.0
1958	1,030.0	858.1	171.9
1959	1,163.9	941.6	222.3
1960	1,268.6	1,024.5	244.1
1961	1,318.3	1,081.3	237.0
1962	1,486.2	1,174.6	311.6
1963	1,597.2	1,254.0	343.2
1964	1,793.3	1,377.7	415.6
1965	1,964.8	1,516.9	447.9
1966	2,203.0	1,710.1	492.9
1967	2,275.4	1,860.8	414.6
1968	2,520.9	2,026.1	494.8
1969	2,796.2	2,242.6	553.6
1970	2,808.2	2,354.4	453.8

1/ Before Federal Income Tax

Noncommercial TV Stations in Operation

Year	Total	VHF	UHF
1955	9	-	-
1960	44	-	-
1965	88	54	34
1966	105	61	44
1967	118	67	51
1968	146	71	75
1969	172	76	96
1970	182	77	105
1971	196	85	111

Commercial Aural Broadcast Stations in Operation

Year	AM	FM
1945	884	46
1950	2,086	733
1955	2,669	552
1960	3,456	678
1965	4,012	1,270
1966	4,050	1,446
1967	4,117	1,631
1968	4,171	1,779
1969	4,236	1,944
1970	4,319	2,184
1971	4,323	2,196

AM-FM Financial Data
($ Millions)

Year	Revenues	Expenses	Income 1/
1952	$ 468.6	$ 407.5	$ 61.1
1953	474.6	418.8	55.8
1954	448.8	406.3	42.5
1955	452.3	406.0	46.3
1956	479.2	429.6	49.6
1957	515.2	460.8	54.3
1958	520.6	482.6	38.0
1959	555.7	511.7	44.0
1960	591.9	543.6	48.3
1961	583.6	551.6	32.0
1962	626.8	580.1	46.7
1963	669.7	611.6	58.1
1964	719.2	645.4	73.8
1965	776.8	695.7	81.1
1966	852.7	752.1	100.6
1967	884.7	799.7	85.0
1968	994.7	877.4	117.3
1969	1,040.3	929.2	111.2
1970	1,136.9	1,044.0	92.9

1/ Before Federal Income Tax

Noncommercial FM Stations
in Operation

Year	Number
1945	--
1950	48
1955	122
1960	162
1965	255
1966	269
1967	299
1968	326
1969	362
1970	396
1971	440

REFERENCE
MATERIAL

The following material on broadcasting and regulation is obtainable from the Commission Office of Information on request.

Applications	How to Apply for a Broadcast Station (1968)
Fairness	Applicability of the Fairness Doctrine in the Handling of Issues of Public Importance (1964)
FCC	What You Should Know About The FCC (1968)
	Lists of FCC Publications Sold by the Government Printing Office (1969) noting that rules governing broadcasting (Volume III of FCC Rules & Regulations) can be purchased for $7
Lists	Radio Stations and Other Lists (1968) noting commercial sources, since the FCC does not furnish station, frequency, or equipment lists
Programing	FCC Report and Statement of Policy Concerning Broadcast Programing (1960)
Publications	Publications and Services (1965) listing business media in the broadcast field
Sponsorship	Applicability of Sponsorship Identification Rules (1963)